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# [A]gricultural Research

## Three-Pronged Attack on Crop Pests (page 4)

## IPM—Integrating the Best of Current Knowledge

There's good news for farmer and consumer alike: Scientific technology is catching up with environmental needs.

After Rachel Carson's groundbreaking book "Silent Spring" appeared in 1962, a long-neglected idea in management of crop pests and weeds began to find new life and take hold—"integrated control."

Today we call it "integrated pest management," but it still stands for the same thing: a multi-faceted approach to pests that uses *all* the weapons science and nature give us.

Twenty years ago, the Agricultural Research Service worked to ensure the quantity and quality of the U.S. food supply mainly through evaluation of new pesticides. Thanks to new scientific knowledge, today we have more diverse opportunities for acceptable and sustainable means of managing pests.

Now more than 80 percent of our pest control research is aimed toward developing biologically based alternatives to conventional pesticides. The remaining 20 percent focuses on technologies and systems to reduce pesticide use and improve application timing, safety, and efficiency when pesticides are necessary.

Integrated pest management—IPM—combines our best current knowledge about biological control, host-plant resistance, and farming practices with chemical controls *as needed* to provide the most environmentally sound, effective control of weeds and pests.

Chemicals are just one weapon in a growing arsenal that also includes beneficial insects, cultural practices, and other environmentally friendly means of protecting our food supply.

IPM definitely demands more strategy and patience than in the days of quick and potent chemical treatments. The agricultural producer who uses IPM has to know exactly which pests to treat and how long to wait to act before crop losses from those pests reach economically unacceptable levels. Fortunately, years of scientific studies have already pinpointed the right time to strike most effectively against many pests.

Part of the answer could be as old-fashioned as mechanically killing a weed, rather than spraying it with chemicals, or temporarily switching to a crop that insect pests won't find as tasty.

But knowledge that we may not have possessed 30 years ago also comes into play, such as which beneficial insects could eliminate the unwanted invaders without eventually becoming pests themselves. Under IPM, all these measures might be used, along with judicious amounts of pesticides when necessary, to ensure maximum agricultural production with minimal environmental impact.

A cornerstone of successful IPM is cooperation among producers. To work, it must be implemented over widespread areas.

One example is ARS' current focus—with cooperating agencies—on an areawide pilot project to control codling moths, an apple pest in the Pacific Northwest.

Typically, codling moths are battled in apple and pear orchards with multiple sprays of organophosphate insecticides. Unfortunately, the result all too often is increased chemical resistance in the pests, plus the destruction of valuable beneficial insects that might have been effective as natural weapons against the moth.

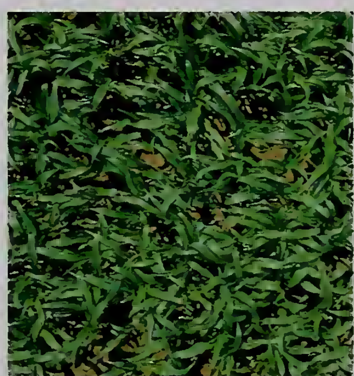
Now codling moths are being stopped by disrupting their mating with a synthetic copy of the female moth's own sex attractant. Males can't find a mate, and apples are protected because offspring aren't produced. As part of an IPM strategy against codling moths, this could help reduce the half-million pounds of active insecticide used each year on 170,000 acres of apples in Washington alone.

This project is just one example of how we're using cutting-edge technology, employing new expertise to produce an attractant that can fool moths. IPM isn't a new idea, but the new knowledge that we bring to it every day from research areas such as insect behavior and chemical ecology give it a brand-new luster of promise for everyone who counts on American agriculture.

**James R. Coppedge**
ARS National Program Leader
Applied Entomology

# Agricultural Research

**Cover: Entomologists Everett Mitchell and Rufina Ward will enclose this cabbage in a cage with parasitic *Cotesia plutellae* wasps. Exposure to the scent of diamondback moth-damaged plants may help the wasps learn to track their prey better.** (K5491-11) Photo by Keith Weller.



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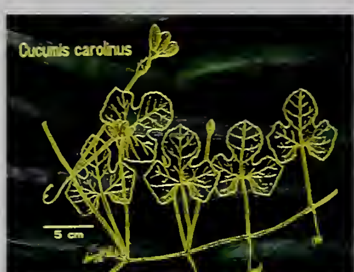


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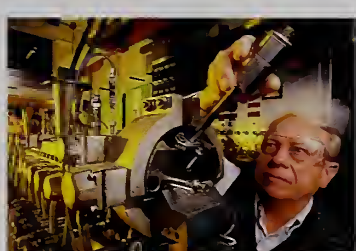

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# Assault on the Senses

## Pheromone Overload Is First in Three-Pronged Attack on Crop Pests

Cabbage leaf damage caused by diamondback moth larvae. (K5495-1)

Let's say you associate a friend at work with his aftershave lotion or her perfume. If the scent is strong enough, you might be able to locate the person by following it.

But what if you took 50 or 100 bottles of the lotion or perfume, opened them, and placed them in all the rooms and corridors in your office building? It would be almost impossible to track one person's scent because it would be everywhere. Eventually, if you were in that environment long enough, you'd get used to the smell and might not even realize it was there.

Such an assault on the senses is part of a strategy Agricultural Research Service entomologists Everett Mitchell and John McLaughlin and their cooperators are taking to control pests that attack cabbage, broccoli, cotton, tomatoes, and other crops.

The idea is to flood a crop field with insect sex attractants called pheromones. Females release these perfumelike chemicals when they're ready to mate, explains Mitchell.

"Normally the male would follow a pheromone trail and find the female," he says. "But in our test plots, we put out pheromone dispensers that make it seem like there are thousands of females everywhere. The males are overwhelmed, confused, and don't know where to go. Eventually, they become so used to the smell that they don't perceive it as a pheromone anymore."

As a result, the males wander around from one reproductive dead end to another. Matings drop off, meaning insect populations—and accompanying crop damage—decline.

For added protection, the researchers are also releasing parasitic wasps to attack larvae that develop from any eggs laid by those females that do manage to find a mate. And if any larvae survive the first two controls, the scientists apply Bt insecticide—because *Bacillus thuringiensis* doesn't harm the wasps, and the pests have not yet developed resistance to some types of Bt, a natural organism.

This is a relatively new, integrated approach to controlling insect pests, but one that may become more common in the years ahead as crop-eating insects develop resistance to insecticides—and as fewer chemicals become available because of environmental concerns.

"The USDA and Environmental Protection Agency have set a goal of having 75 percent of U.S. cropland under integrated pest management by the year 2000," says James Coppedge, the ARS national program leader for applied entomology. "To meet that goal, we have to have alternatives that farmers can use in the field. This is a good example of such an alternative."

Looking for alternatives is the primary goal of Mitchell, McLaughlin, and other researchers at the agency's Insect Attractants, Behavior, and Basic Biology Research Laboratory in Gainesville, Florida.

The lab was established in the late 1960's in the aftermath of Rachel Carson's book "Silent Spring," which raised public awareness about the potential dangers of chemical pesticides and their impact on the environment. Since then, lab scientists have been working with pheromones, parasites, and other nonchemical ways to control insect pests.

Several years ago, Mitchell and McLaughlin—who was formerly at Gainesville and is now based at the agency's Shafter, California, facility—began small-scale studies of the three-pronged approach to controlling the diamondback moth (*Plutella xylostella*) that attacks cabbage, broccoli, cauliflower, watercress, mustard, and other related crops. The scientists are also continuing prelimi-

USDA and the U.S. Environmental Protection Agency have set a goal: 75 percent of U.S. cropland under integrated pest management by the year 2000.

KEITH WELLER

**Using a night scope and a red-filtered flashlight, entomologist John McLaughlin checks a mating table placed in a cabbage field to monitor activity of female diamondback moths. (K5493-1)**

KEITH WELLER

**Pheromone dispenser. (K5492-10)**

KEITH WELLER

Biological technician Jack Rye installs combination cabbage-looper and diamondback moth pheromone strips amid 3-week-old cabbage plants. Placed about 12 feet apart, they are designed to confuse males in pursuit of mates. (K5494-15)

nary studies of other pheromones and parasites for use against fall armyworm, beet armyworm, cotton bollworm, and other insects that attack cotton and other crops.

## Of Cabbages and Moths

The diamondback has had a marked impact on cabbage production in Florida, playing a large role in the decline from 19,600 acres in 1984-85 to 11,600 acres in 1991-92, according to Florida statistics. The pest put some growers out of business and threatened others.

"Cabbage isn't a high-value crop, so it's not worth growing if a farmer's pest control costs are too high," notes Robert Johnson, a private agricultural consultant who worked with Mitchell and McLaughlin on the study.

Pyrethroids were introduced in 1980 to control the diamondback, but by 1985 they were ineffective because the insect had developed resistance to them, Mitchell says. "We're concerned that the moths have begun to build up resistance to Bt as well. So we're trying to come up with an alternative for growers so they can control the diamondback moth and other pests."

The researchers took the pheromone disruption idea to the field in 1990-91 in a 20-acre test on cabbage at Zellwin Farms, in Zellwood, Florida. In that study, they released the pheromone in ropes made by the Shin-Etsu Chemical Co. of Japan that were stretched across the field about 1 foot above the ground and up to 30 feet apart. Each rope was actually a flexible wire attached to a permeable tube containing the pheromone. Over 10 weeks, they tracked moth populations, comparing them to two conventional fields nearby. One field was sprayed 13 times and the other, 15; insecticides used included pyrethroids, organophosphate, and Bt.

The results were encouraging. The researchers collected females in both pheromone and control fields and examined them to see if they had mated. In the pheromone-treated plots, only 36 percent had mated, compared with 86 percent in fields where the attractants were not used, Mitchell says.

"Cabbage yields and quality were also comparable, and we only had to spray three times in our test plots. But you don't always stop 100 percent of the reproduction among the pests, so we felt that to get better control, we'd need the other two components—parasites and selective Bt spraying."

Subsequent small-scale field tests in 1992-93 led the researchers to seek funding to test this three-pronged system on a larger scale. Last year, they received a grant to begin a 3-year pilot study to control the diamondback.

In the 1992-93 tests, they treated 70 acres of cabbage on a farm near Orlando using the continuous ropes. They also used the same pheromone in quarter-acre plots, but they released it in 8-inch dispensers attached to stakes or inserted into the soil, rather than as ropes. "The grower we worked with said the ropes made it harder to use mechanical equipment in the field," Mitchell says. "The stakes are low enough so that the equipment easily passes over them."

KEITH WELLER

Entomologists John McLaughlin (left) and Everett Mitchell check a cabbage leaf for larval damage. White pheromone ropes (foreground and background) are laced with diamondback moth sex pheromone. (K5489-1)

In those tests, the scientists also released 25,000 *Cotesia plutellae,* a parasitic wasp mass-reared by a Texas company, on 50 acres of cabbage at a rate of 200 wasps per acre. This parasitic wasp—harmless to people or other insects—lays its eggs in diamondback moth larvae. As the parasites develop, they feed on the larvae and prevent them from evolving into adult moths.

The effect of *C. plutellae* was limited: only about 7 percent of moth larvae recovered had been parasitized, says Mitchell, who plans to increase the rate of release to 600 wasps per acre during the 1994-96 pilot study.

The researchers are also teaching the wasps to do a better job of finding their prey. To do that, they're placing wasp cocoons in small cages containing radishes or cabbage and the moth larvae. "As the wasp adults emerge, they are exposed to the odor of plants damaged by the feeding of diamondback larvae. This helps the wasps get used to the smell of the vegetable and to associate it with the targeted pest," Mitchell says. "We hope this will teach the wasps to better locate their prey." [For more information on this concept, see "Beneficials Are Money in the Bank," *Agricultural Research,* February 1993, pp. 20-22.]

The scientists also found that a native parasitic wasp called *Diadegma insulare* parasitized 24 percent of the larvae collected—better than three times the rate of *C. plutellae.*

"But the problem is that *D. insulare* is difficult to rear and isn't available commercially," Mitchell says. "We're working on rearing methods for *D. insulare* so we can release it in future tests."

Mitchell hopes that by 1996—the last year of the pilot study—"we'll have technology a grower can use on a cost-effective basis in the field." Pheromone treatment is expensive—$300 per acre for the rope formulation, excluding the cost of installation—and cabbage is a low-value crop. At $5 per crate, a farmer could expect to make from $1,500 to $2,000 per acre, based on 300 to 400 crates. Three hundred to 350 crates per acre is considered break-even.

Mitchell says the pheromone approach will become more cost-effective in the future—particularly if pheromones can be added to control more than one pest. In 1994, they are testing this approach by combining, in one dispenser, pheromones to control two pests—the diamondback and the cabbage looper.

"We think the cost of pheromones will come down as pesticide regulations become more stringent," Mitchell says. "If growers know they can make money using our biocontrol approach, then they'll use it.

"They'll have to do things differently; instead of spraying chemicals, they'll have to schedule parasite releases. But we think in the long run, it'll be worth it," he says.—By **Sean Adams,** ARS.

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# Narrower Rows, Higher Planting Density Cut Corn Herbicide Use

CRAIG DAUGHTRY

CRAIG DAUGHTRY

**Top: Corn is normally seeded at a rate of 26,000 plants per acre, planted in 30-inch rows. (94-52)**

**Bottom: Leaf canopy closed more quickly and deterred weed development in test fields with high-density planting. (94-53)**

Herbicides were cut 75 percent on no-till cornfields—without sacrificing yields—when the number of plants was doubled by narrowing the row spacing from 30 to 15 inches, a U.S. Department of Agriculture scientist reports.

John R. Teasdale of USDA's Agricultural Research Service says doubling the number of corn plants from 26,000 to 52,000 per acre in narrower rows produced an average 150 bushels an acre—the same as yields from the standard plantings on no-till fields.

Yields were based on the first 3 years of a 1989-92 study at the ARS Beltsville (Maryland) Agricultural Research Center.

Teasdale, a plant physiologist at the center's Weed Science Laboratory, says the herbicides used were atrazine and metolachlor. On plots with narrower rows and higher density, the same yield was achieved with only one-quarter pound of atrazine and one-half pound of metolachlor per acre—a fourth the normal rates.

"That's because the narrower rows and higher density of corn plants more rapidly create a leaf canopy that blocks sunlight from reaching weeds, preventing their growth," he says.

"Herbicides are needed to control weeds primarily during the period before the corn leaf canopy closes. Faster canopy closure with narrow rows and high planting density will mean significantly less herbicide than recommended in many cases."

Teasdale says that while much research has been done on the effect of row spacing and planting density with soybeans, less has been done with corn. Nearly all the nation's corn and soybeans are treated with herbicides—particularly on no-till fields, which farmers do not plow, to cut down on soil erosion.

An estimated 500 million pounds of herbicide are used on U.S. cropland, with about 200 million pounds applied to cornfields alone. Atrazine and metolachlor are among the most widely used herbicides—atrazine to control broadleaf weeds such as velvetleaf, pigweed, and lambsquarter, and metolachlor to kill grasses such as foxtail and crabgrass.

"These chemicals are called preemergence herbicides—meaning they are applied to the soil before crops emerge," Teasdale says. "That makes them more prone to movement into groundwater and surface water."

The narrow-row planting required fewer equipment changes than expected, for corn can be planted with a no-till planter equipped with a splitter to insert the narrow rows. And a combine with a conventional corn head harvested the 15-inch rows as efficiently as 30-inch rows. However, narrow tires are necessary for postemergence agronomic operations, such as sidedressing nitrogen.

The only drawback to narrow-row corn spacing—at least in the short term—is economic. Teasdale says the cost of planting more seed per acre could outstrip the herbicide savings by up to $10 per acre. But if herbicides now used are eventually restricted, farmers may be forced to use other, more expensive herbicides.

Teasdale and ARS agronomist C. Ben Coffman, also of the Weed Science lab, have begun additional studies to see if corn can be planted at less-expensive, lower seeding rates in the 15-inch rows and still maintain yields with less herbicide.—By **Sean Adams,** ARS.

*John R. Teasdale is at the USDA-ARS Weed Science Laboratory, Bldg. 001, 10300 Baltimore Ave., Beltsville, MD 20705; phone (301) 504-5504, fax (301) 504-6491.* ◆

# Everything You Ever Wanted To Know About Melons and Cucumbers

Detailed information about melons and cucumbers is showing up on computer screens for the first time.

"We've used computer graphics to make it easy for plant breeders and other users to get instantaneous pictures from user-friendly diskettes of plants in the genus *Cucumis,*" says Agricultural Research Service botanist Joseph Kirkbride, Jr., a world expert on the genus.

*Cucumis* includes two crops of major economic importance: cucumbers and melons—including honeydews, cantaloupes, and casabas.

Kirkbride worked 7 years collecting information and researching *Cucumis* for the monograph issued as both a database and hard-copy publication.

The 159-page text, titled *The Biosystematic Monograph of the Genus Cucumis,* is published by Parkway Publishers of Boone, North Carolina. It comes with a 5 1/4-inch microcomputer diskette in an electronic format accessible via MS-DOS computer.

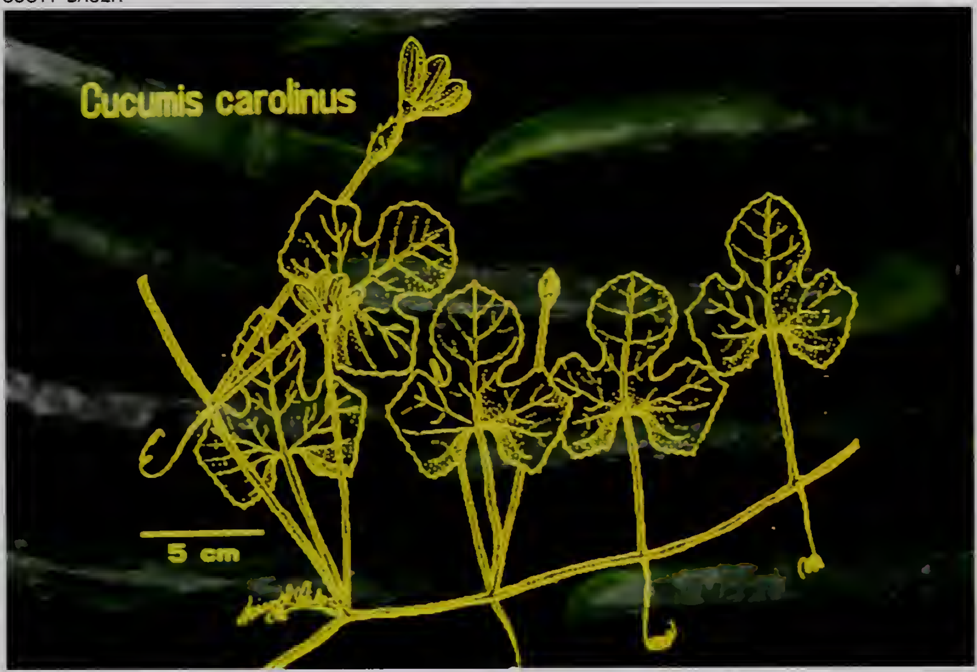
Distributing this type of detailed information in electronic format allows the data to be manipulated and customized to fit specific needs. With appropriate software, the information can be accessed in many ways.

It gives users easy access to black-and-white graphic information of features such as leaf characteristics, making it easy to actually see what a plant looks like and to trace the species they are working with.

"We've wedded computer technology with the dynamic science of systematics for the genus *Cucumis,*" Kirkbride says. Systematic botany is the science of plant identification and classification.

He says, "Presenting so much detailed information on computer diskettes eliminates the somewhat tedious job of sifting through several hundred pages of descriptions and drawings."

SCOTT BAUER




**Computer images of leaf characteristics and other features of cucumbers aid rapid specimen identification. (K5486-7)**

Every known member—over 5,000 samples—of the 32 diverse species of *Cucumis* is described. Included is information on the genus and the taxonomic history and morphology of its species, as well as pertinent data on its flavonoids, isozymes, DNA, and crossability.

Kirkbride says, "Because many cultivars of cucumbers and melons are susceptible to diverse fungal, bacterial, viral, and insect diseases that reduce both crop yield and quality, the study of *Cucumis* diseases is of significant economic importance."

So, intensive investigations are under way at several ARS laboratories to discover resistance to many of them—especially in wild species.

"Much of this wild germplasm isn't susceptible to a whole list of diseases that attack cultivated members of the species," says Kirkbride.

According to botanist Calvin R. Sperling, a plant exploration officer for the ARS National Germplasm Resources Laboratory at the Beltsville center, "ARS plant breeding programs are working with both wild and cultivated species of *Cucumis* acquired from explorations to India and other countries.

"Wild relatives of *Cucumis* are becoming more important because of new gene transfer techniques that make it possible to move desirable traits from wild to cultivated plants."

Amy Y. Rossman, who is in charge of the ARS Systematic Botany and Mycology Laboratory where Kirkbride works, at the Beltsville (Maryland) Agricultural Research Center, says of his accomplishment, "This work heralds the beginning of an electronic age for systematic botanical data.

"Using expert systems for communicating detailed and tedious information about a plant genus makes this important information readily available to more users," she says. "No longer does a plant breeder need to send a specimen out for an accurate identification. Now, this can all be done at the user's lab."—By **Hank Becker,** ARS.

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# Streambed Erosion

## Measuring Sediment's Ebb and Flow

Two new devices have been developed and are being tested to help solve the mystery of how coarse sand and gravel—products of channel erosion—are moved by flowing water along the stream bottom.

"For channels in agricultural and other watersheds to remain stable, there must be a sediment transport balance," says ARS hydraulic engineer Roger Kuhnle. "This means that the amount of sediment moving into a part of the channel must equal the channel's capacity to move the sediment out of that channel segment.

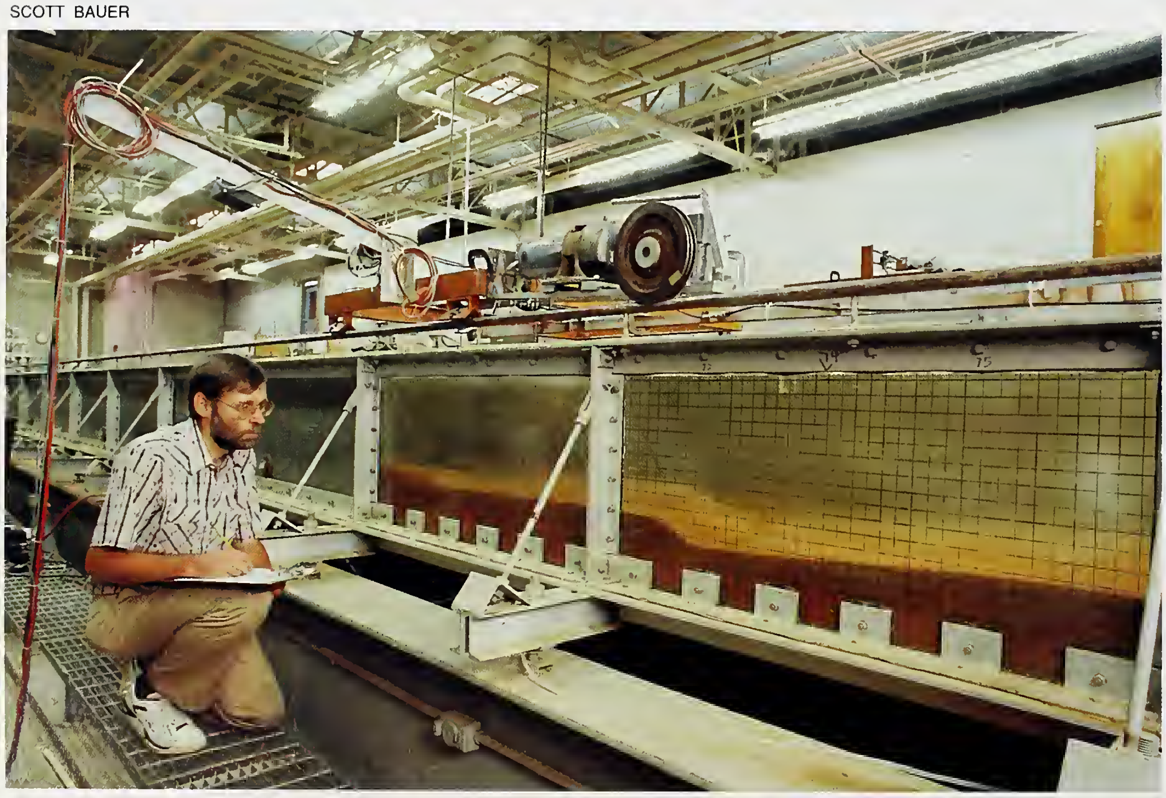
"Otherwise," he says, "sediment will either be deposited—ultimately filling the channel and impeding waterflow—or the force of the moving water will erode the channel banks and bed to restore the balance."

Kuhnle has spent 8 years at the USDA's National Sedimentation Laboratory (NSL) in Oxford, Mississippi, studying the effects of waterflow on the transport of sediment.

SCOTT BAUER

**Before running an experiment in the model stream channel, hydraulic engineer Roger Kuhnle (left) and technician John Cox measure the water's depth and adjust the height of the ultrasonic sensors. (K5199-9)**

SCOTT BAUER



**Hydraulic engineer Roger Kuhnle records the type of underwater sand dunes formed by varying waterflow and sediment movement rates. (K5198-8)**

Information on sediment movement is critical to engineers in the U.S. Army Corp of Engineers, to the USDA's Soil Conservation Service, and to others responsible for the ecological and environmental stability of watershed drainage systems.

"Too much or too little sediment movement in natural channels can cause several problems. An excess can fill reservoirs and decrease their capacity to store water, reducing their benefits to society during floods and droughts. Sediment can fill stream channels, which exacerbates downstream flooding. It can also be harmful to aquatic life and the quality of water," Kuhnle says.

But too little sediment causes the bottom of many steep upland channels to erode, which in turn causes the streambanks to become unstable, collapse, and destroy the profitable use of adjoining land.

"In spite of the importance of sediment movement along channel bottoms, no equations have been developed that adequately predict the rates of sediment movement for a given flow," he says.

According to Kuhnle, obtaining accurate measurements of sediment movement is very difficult. There is a high degree of variability in the rate of this movement in both time and location. And it is difficult to know the right place and time to sample. For some streams, significant sediment movement may occur only a few days each year.

To improve our understanding and measurements of sediment movement by water, Kuhnle helped to develop two measuring devices—a sampling box for collecting coarse sediment and a sonar detection system for tracking sediment movement.

In 1988, at a site on Goodwin Creek in northern Mississippi, the first 4- by 2- by 4-foot aluminum sampling box with three openings

along its top was constructed to trap sand and gravel as they move along the bottom of the stream.

The box sampler was installed in the bed of the stream with the top of each compartment flush with the stream bottom. During heavy rainstorms, when flowing water causes the sediment on the stream bottom to move, a computer automatically records the rate of sediment accumulation in the boxes, until they are filled, Kuhnle explains.

After the rain stops, a chain hoist located above the boxes lifts them from the water for sample collection and emptying. Then the boxes are lowered back into the streambed, ready for the next storm. Rates of sediment movement during the storm are related to measured flows of water in the channel.

"Compared with manual sampling, the box sampler has two major advantages: It automatically operates during storms, continuously collecting data on sediment movement. It also gives the researcher the freedom to remain indoors when it's raining," Kuhnle says.

After 3 years of operation at two sites on Goodwin Creek, the box sampling technique has provided valuable data on the movement of sediment after 18 rainstorms.

"We found as much as a four-fold difference in the rate of sediment movement—depending solely on whether the water level was rising or falling—for comparable waterflow on two streams," Kuhnle says. "These findings are very important because, for many streams, most of the sediment movement occurs when the waterflow rate is unsteady. Existing models of sediment movement wouldn't have predicted this variability."

SCOTT BAUER

**Hydrologic technician John Cox uses a chain hoist to lift the streambed sampler's inner boxes. (K5198-11)**

More recently, Kuhnle has been working on a new technique to measure sediment movement along a stream channel, using an acoustic distance-measuring device.

Building on the work of retired ARS hydraulic engineer Joe Willis and others, Kuhnle and hydraulic technician John Cox developed a technique to measure the rate of sediment movement by measuring the size and speed of dunes, the temporary underwater sand ridges that migrate along the bottoms of streams.

The acoustic device, called the SedBed Monitor, was developed by researchers at the University of Mississippi's National Center for Physical Acoustics in Oxford. The developers relied on Kuhnle's expertise to apply the technology to sediment movement.

Currently, Kuhnle is evaluating the SedBed Monitor in a 4- by 100-foot plexiglass test channel in the NSL's hydraulics laboratory.

To test the technique, the channel is filled with sand and water that are recirculated by an adjustable-speed pump. This allows simulation of a wide range of waterflow and sediment movement rates.

"Sound that bounces off sediment as it moves along the bottom of the stream is picked up by a special microphone and fed into a computer. Within minutes, the computer can display or print out a graphic image of the changing topography of the stream bottom," says Kuhnle.

The size, migration rate, and density of dunes on the bottom are then used to calculate the rate of sediment movement in the test channel.

"Obtaining an accurate average rate of sediment movement, using conventional sampling methods at a given location, would take hours because of the variable nature of sediment movement," he adds.

This acoustic technique will be used to continue research on the effects of unsteady waterflow on the movement of sediment in streams.

Kuhnle believes that the SedBed Monitor will prove invaluable to hydraulic engineers and others who need better information on the dynamics of sediment flow near the bottom of streams. It will yield information needed for testing existing models and for developing new models of sediment movement in streams and rivers.—By **Hank Becker**, ARS.

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# Russian Wheat Aphids Leave Glowing Tracks

When Russian wheat aphids dine on tender young barley plants, they leave a trail of microscopic puncture marks on the leaves.

Scientists are finding that the more of these tracks on a leaf, the better. It's a sign that the aphid didn't find good eating or—in the parlance of the plant breeders—the plant has genetic resistance to aphid feeding.

Studies suggest that the plants with the most puncture marks are actually less palatable to the aphids, causing the pests to keep on probing in search of a more tasty spot.

Plant physiologist Helen Belefant-Miller, formerly at the ARS Plant Science Research Laboratory in Stillwater, Oklahoma, and her ARS and Oklahoma State University colleagues discovered the punctures made by the aphids' mouthparts.

Plant cells around the punctures collapse and emit a faint glow under ultraviolet light, an effect called autofluorescence. By counting the glowing sites, researchers can determine which leaves are probed most often.

"We can identify aphid-resistant plants in a single day, compared with the 3 weeks normally required to test barley seedlings for resistance," says ARS geneticist David R. Porter, who is also at Stillwater. "Autofluorescence is the fastest plant response to Russian wheat aphids seen so far."

Before the discovery, researchers calculated a barley plant's resistance based only on a numerical damage score for advanced symptoms, such as white-streaked leaves or leaves that fail to unroll as they grow.

Previously, scientists had seen autofluorescence in plants only as a result of infection by disease-causing microbes. The discovery that Russian wheat aphid attacks elicit a similar response is one of the few clues, to date, as to the biochemical basis for some plants' resistance.

In feeding studies, the scientists measured the behavior of the 2-millimeter-long green aphids on resistant and susceptible barleys. To do this, they used minute strands of gold filament to tether the aphids to electrical recording devices. They also wired the plants to the recording devices. As the aphids probed the plants to feed, they completed an electric circuit, and the voltages were inked out on a strip chart.

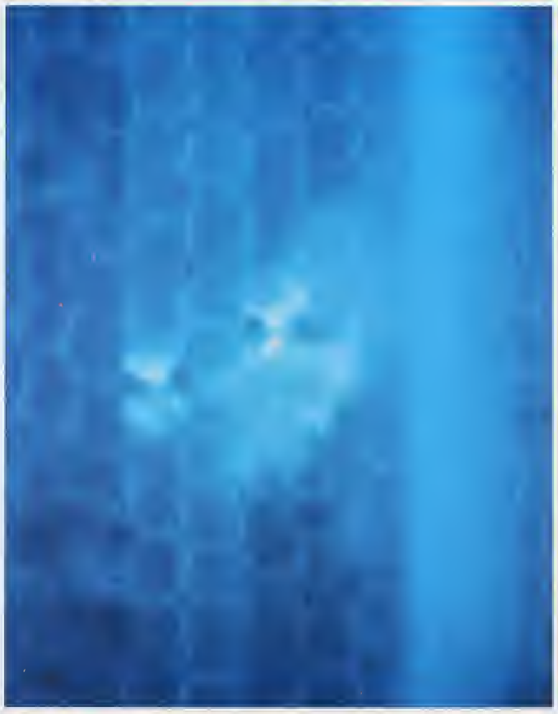
Because these records showed that Russian wheat aphids spent less time feeding on resistant barleys and probed the resistant plants more often, researchers concluded the aphids kept searching in vain for desirable feeding sites.

"The aphids' probing into leaves may stimulate the plant to immediately produce autofluorescent material in nearby cells," says Porter. Further research to identify the material and learn how it is made could help scientists understand genetic regulation of the response.—By **Ben Hardin,** ARS.

*David R. Porter is at the USDA-ARS Plant Science and Water Conservation Research Laboratory, 1301 N. Western St., Stillwater, OK 74075; phone (405)-624-4212, fax (405) 372-1398.* ◆

HELEN BELEFANT-MILLER

HELEN BELEFANT-MILLER



**Left: Under an ultraviolet light microscope, glowing spots show where Russian wheat aphids successfully fed on this susceptible barley leaf.**
**Right: Clustered spots indicate multiple probes by aphids attempting to feed on a resistant barley obtained from the USDA-ARS National Small Grains Collection at Aberdeen, Idaho.**

# Insect Drafted To Fight Fungus It Spreads

In the summer of 1993, hundreds of dark-brown, hairy insects called dusky sap beetles were recruited by ARS researchers to protect corn from the *Aspergillus flavus* fungus.

The scientists' weapon: a natural enemy of the fungus that causes aflatoxin in field corn before it can be harvested. The insects' pay: as much corn as they wanted to eat.

Under normal circumstances, dusky sap beetles themselves damage corn by feeding. They enter through wounds caused by corn earworms or borers, or through gaps in the husk. What's worse, while the beetles feed on field corn, they also spread fungal spores including the *A. flavus* that produces aflatoxin.

But now, entomologists Fernando E. Vega and Patrick F. Dowd at the National Center for Agricultural Utilization Research (NCAUR) in Peoria, Illinois, have invented a delivery system for a biological control that, in effect, turns the quarter-inch beetle from villain to hero.

Last summer, Vega and Dowd used a commercial preparation of *Bacillus subtilis* provided by Gustafson, Inc., of Dallas, Texas, to test their system in the field. The *B. subtilis* bacterium is a natural enemy of *A. flavus* and another fungus, *A. parasiticus*.

The researchers designed and tested a dispenser to hold the bacterium inside a baited trap. The trap's bait consists of pheromones—sap beetle attractant chemically synthesized by NCAUR entomologist Robert J. Bartelt—and artificial host-plant odors.

KEITH WELLER

**Dusky sap beetle on a damaged ear of corn. (K5499-1)**

Drawn by the enticing aromas, beetles enter a T-shaped plastic trap and crawl into a container, where their hairy bodies pick up microorganisms such as *B. subtilis* that have been placed there. The trapped beetles panic, exit the device, and scurry off to corn fields, spreading the *B. subtilis.* ARS has applied for a patent on the biocontrol device.

In their tests, Vega and Dowd artificially infected field corn with *A. flavus.* They placed the biocontrol device containing beetles and *B. subtilis* 10 feet from a corn row. Ears that had been visited by the beetles before *A. flavus* was added were fully protected, while ears that were inoculated first with *A. flavus* had a 92-percent infection rate.

To eliminate any later problem from the beetles themselves, "an insect pathogen could be added to the device just before the beetles begin moving to overwintering sites. Harmless to plants and animals, the pathogen would kill the sap beetles after they gathered to overwinter," says Vega.

This sap beetle delivery system could be used to combat other plant pathogens the beetle spreads to peaches, nectarines, dates, and figs. It could also be tailored so as to have insects carry pathogens to weeds on which the insects feed.—By **Linda Cooke,** ARS.

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KEITH WELLER

**A T-shaped autoinoculator designed by entomologists Patrick Dowd (left) and Fernando Vega lures dusky sap beetles inside, where the hairy insects pick up biocontrol microorganisms for delivery to fungus-infected corn. (K5498-1)**

# Putting the Bite on Caribbean Fruit Flies

Bite into an apple and you hear the crunch of your teeth through the skin and into the fruit. On a smaller scale, fruit fly maggots can be heard eating their way through grapefruit pulp.

We can't hear the maggots nibbling, but parasitic wasps can. One way these wasps hunt for a maggot meal for their offspring is by listening to the maggots eat.

Once a female wasp finds a maggot, she sticks her ovipositor through the fruit peel and lays an egg inside the maggot. Within a short time, the maggot leaves the fruit and develops into a pupa. Later, the wasp egg will hatch into a larva that will begin to eat the maggot pupa.

John Sivinski and scientific cooperators have released millions of these parasitic hunter wasps to suppress the Caribbean fruit fly in Florida. It's part of a 4-year pilot study to use the *Diachasmimorpha longicaudata* wasp to maintain and expand a buffer zone free of the flies, which attack citrus and other fruits.

The scientists released 50,000 to 150,000 wasps per square mile each week and were able to reduce fruit fly populations by 90 to 95 percent.

Maintaining a fruit-fly-free zone allows Florida citrus growers to export fruit to California, Japan, and other areas that refuse fruit unless it is grown in fly-free zones. Fruit flies are among a number of pests subject to such quarantine restrictions.

Previously, growers used the fumigant ethylene dibromide (EDB) to kill fly larvae in fruit, but the U.S. Environmental Protection Agency has suspended EDB because it was found to be carcinogenic.

Sivinski notes that other alternatives to EDB have also run into trouble. Citizens in urban areas have objected to aerial spraying of malathion, while citrus growers are uneasy about releasing sterile males to suppress fruit fly populations.

"They're concerned that if sterile flies are trapped, it could complicate certification of their groves as fly-free," says Sivinski, an entomologist with USDA's Agricultural Research Service. "We can tell sterile and wild flies apart, but growers are worried that identifying the flies could cause delays and jeopardize shipments."

So Sivinski entered into cooperation with Carroll Calkins of ARS,

KEITH WELLER

**A female *Diachasmimorpha longicaudata* wasp stalks the surface of a mango, locating maggots by the sounds they make as they move and feed. (K5488-1)**

Richard Baranowski with the University of Florida, Donald Harris and Ed Burns with the Florida Division of Plant Industry, and Tim Holler of USDA's Animal and Plant Health Inspection Service.

They focused on using biological controls as a viable alternative for protecting fly-free zones. Their aim was to create buffer zones in urban areas next to commercial groves by releasing parasites to drastically lower fruit fly numbers. Urban backyard gardeners often raise guava, loquat, Surinam cherry, and other fruit trees. Fruit flies migrate from them into commercial citrus, after feeding on the fruits.

Growers first found the Caribbean fruit flies at Key West, Florida, in 1931. That prompted regulators to begin a quarantine that lasted until 1936, when populations declined. The fly resurfaced at Key West in 1959 and then disappeared again until 1965, when regulators found larvae in Surinam cherries in Miami Springs. Since then, the fly has spread to 30 counties throughout southern and central Florida.

Over the years, researchers have introduced 15 different species of biocontrol wasps to control the pest. Five of those species have become established, but the fly still remains a serious problem for several reasons, Sivinski says.

"Often the fly larvae are so deep in the fruit that the wasp's ovipositor can't reach them," he says. "Also, the flies tend to reproduce faster than the wasp parasites, so the fly populations outstrip the parasites.

"That's why we're releasing millions of the wasps at a time when fly populations are starting to build up. This gives the wasps a better chance of finding and parasitizing fruit fly larvae."

There are several factors working in favor of controlling the fly in Florida. For one, the flies infest grapefruit only at low levels—preferring loquat, guava, and other backyard fruits that can be separated from commercial citrus by maintaining the fly-free zones.

*D. longicaudata* has proven to be one of the more effective hunters of fruit fly maggots. Originally from India, Borneo, the Philippines, and other areas, this wasp now accounts for about 95 percent of all fruit fly larvae parasitized in the southern part of Florida.

In the pilot study, Sivinski and colleagues set up two test sites—on Key Biscayne, an island about a half mile offshore from Miami, and at

Clewiston, on the southwest shore of Lake Okeechobee.

At Key Biscayne, during 36 weeks, they released 10 million *D. longicaudata* wasps per square mile over 2 square miles. At Clewiston, they released 3.75 million per square mile over a larger, 5-mile area, but they had to curtail releases after 15 weeks because of trouble in rearing the parasites.

Sivinski said they attempted to release from 4 to 10 times as many parasites as flies estimated to be in the areas, depending on fluctuations in fly populations. Originally, scientists put fly pupae containing parasites in the field; after that, they released adult wasps to hunt their own prey.

Within 5 weeks of the initial adult releases, fly populations at Key Biscayne were at least 95 percent lower than fly populations in nearby areas of South Miami where there were no parasite releases. In the Clewiston release area, fly populations were also substantially lower.

"It seems that the adult wasps were more effective in hunting for fly larvae," Sivinski said. "Putting parasitized pupae in the fields didn't seem to have much of an effect in Florida, although it has been used successfully in Hawaii."

In Hawaii, ARS scientist Tim Wong and colleagues used the braconid wasp *D. tryoni* to suppress Mediterranean fruit flies. In those studies, they released parasitized fruit fly pupae. Sivinski used irradiated fly larvae, to prevent any flies that might escape parasitism from developing into fertile fruit flies.

Sivinski is now expanding the scope of the research in tropical America, where he is working with cooperators in Mexico and Guatemala to set up a fly-free zone against the Mediterranean fruit fly. The work there combines parasite releases and sterile male flies that mate with wild females to produce infertile eggs that do not hatch.

KEITH WELLER

**To help maintain buffer zones between home gardens and commercial orchards, ARS technician Gina Posey releases hundreds of parasitic wasps near a loquat tree. This fruit is a common backyard host of Caribbean fruit flies in Florida. (K5487-1)**

"We're also looking in those countries for new parasites that do a better job of hunting for fruit fly larvae," Sivinski says. "That could make it easier and more cost effective to maintain the fly-free zones."—By **Sean Adams,** ARS.

*John Sivinski is at the USDA-ARS Insect Attractants Laboratory, P.O. Box 14565, Gainesville, FL 32604; phone (904) 374-5791, fax (904) 374-5781.* ◆

## The Chitin Connection

# Developing Plants' Own Self-Defenses Through Biotechnology

**A higher level of defensive enzyme activity in the citrus cell mass on the right (bottom) inhibits the growth of *Penicillium digitatum* (top), a serious postharvest pathogen of citrus.**

RANDALL SMITH

What could a fungus, a crab, a lobster, a shrimp, and a beetle possibly have in common?

They all contain forms of chitin, a substance found in the outer shell of crustaceans and insects and in the cell walls of many fungi. It is chitin that makes that shell, or exoskeleton, hard; it serves as protection against predators.

Plants, too, have many built-in defense mechanisms, but chitin, as such, is not one of them. However, ARS scientists at the U.S. Horticultural Research Laboratory in Orlando, Florida, have found large numbers of related enzymatic proteins in some citrus.

"These are enzymes that break down chitin," explains lab director Richard T. Mayer. "We're hoping to put the genes for these enzymes, called chitinases and chitosanases, into the citrus and other plants that don't have them—or to manipulate the genes already present. This would build into otherwise vulnerable plants natural protection against pathogens, insects, and harmful nematodes."

Mayer hopes that these plant defensive proteins could be exploited as an alternative to methyl bromide, a protectant chemical used extensively in agriculture.

The U.S. Environmental Protection Agency has scheduled methyl bromide to be taken out of production and off the market by the year 2001 because it has been identified as being harmful to the atmosphere.

Of the 64 million pounds used in the United States in 1990, more than 80 percent were used in agriculture. After soil fumigation, commodity fumigation and quarantine are the next largest use for this chemical.

About $1.5 billion in agricultural losses might occur annually as a result of this ban, according to a report by the National Agricultural Pesticide Assessment Program. The estimate does not include the impact on nonquarantine postharvest uses, quarantine treatment of nonfood imports, and some soil fumigation.

"This adds urgency to our research on plant defensive proteins like chitinases," Mayer says. "Our ultimate goal from this research is to put genes into plants that will enable the plants to protect themselves."

Mayer says that plant chitinases and chitosanases can work independently of, or in concert with, each other or with other types of enzymes to degrade invading fungal pathogens.

This is possible, he says, because the pathogens, insects, and nematodes contain chitin and chitosan as structural components in their cell walls and exoskeletons.

Chitin also forms a membrane that lines the digestive tract of insects. This protective membrane serves as a barrier against internal penetration of the insect by bacteria or pathogens. Chitinases would break down or dissolve this membrane, leaving the insect open to infection.

If citrus plants could be engineered to produce more of the defensive

proteins, then the enzymes would counterattack a pathogen or repel insects and harmful nematodes.

Pie in the sky?

"No," says Mayer. "We discovered 20 or more different forms of chitinases and chitosanases in oranges and grapefruit. We are now describing the qualities of and purifying these proteins and are looking for the genes responsible for producing them."

Mayer and colleagues are also studying what activates the genes. "We've found that we can raise the levels of the defensive proteins by applications of simple sugar compounds that are environmentally safe. These elicitors could be incorporated into a grower's routine crop-management scheme," he says. "We also plan to test this approach as a control measure for pests of citrus and other fruit and vegetable crops."

### A Defense Against Whitefly?

Work on one such pest, the silverleaf whitefly, *Bemisia argentifolii* (formerly called the sweetpotato whitefly, *Bemisia tabaci*), is well under way at Orlando.

Entomologist Jeff Shapiro says that when this insect feeds on pumpkin and squash plants, the feeding activity triggers production of a few select proteins in the plant. He is looking for the gene promoters that cause this response. "Once we discover and isolate these DNA promoters, they could be linked to the chitinase genes," he says.

The next step would be incorporating both the promoters and the genes into plants such as citrus, for built-in protection against whitefly.

### Finding Where the Genes Are

Plant physiologist Greg McCollum and molecular biologists Hamed Doostdar and Joseph Nairn are trying to identify the chitinase genes. They are preparing antibodies that are important as a selection tool in identifying the responsible genes.

"We've seen varied responses from the forms of enzymes we've found in citrus," McCollum says. "From the responses, we think these enzymes may be players in defending citrus against pests."

It's the multifunctional aspect of the proteins that fascinates Doostdar.

"We saw that different enzymes are expressed at different times," he says. "Once we have the enzymes purified and the genes identified that produce them, the next step will be cloning the genes and inserting them back into citrus plants to see if the genes can produce the enzymes at high enough rates to give protection."

Could these enzymes protect against whiteflies?

Since the genes must be inserted in the earliest stage of plant growth, Randall P. Niedz, Orlando plant geneticist, has a citrus cell culture ready to go.

"We know that chitinases and chitosanases are in callus [a cell mass that forms during tissue culturing] and that the enzymes have many forms, so we have a lot to work with. We plan to treat callus cells with different substances to see if we can elicit the enzymes," Niedz says.

He plans to challenge the tissue-cultured citrus callus with several different types of elicitors to see what responses are triggered.

"Maybe we won't need a transgenic plant. We could find an elicitor that might be sprayed on a citrus tree to change its normal enzyme levels," says Niedz. "There are lots of possibilities."

In other research at Orlando, scientists found that the levels of chitinase in grapefruit decrease dramatically as the fruit matures. By applying plant hormones, like gibberellic acid, this trend was reversed.

"This is intriguing, especially since the presence of these enzymes appears to correlate with greater resistance to fungal infections and Caribbean fruit fly attacks," Mayer says.

Additional experiments at Orlando show other proteins that also make plants and their fruits undesirable hosts for pests. ARS horticulturist Roy McDonald is working with peroxidases—proteins that limit penetration of disease pathogens and, possibly, insects by increasing the cross-linkage of plant cell wall components.

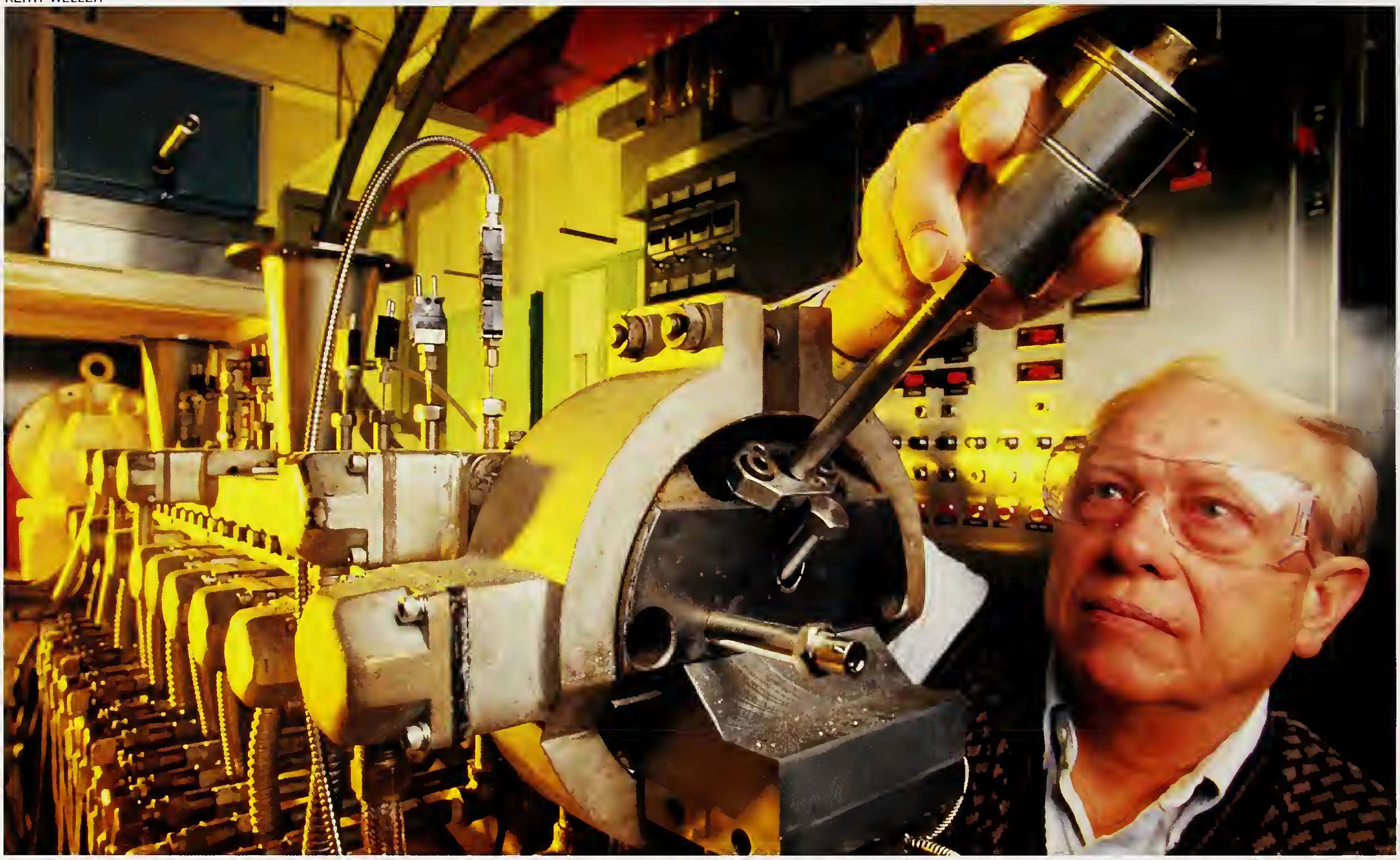
"We've found that several elicitors cause these protective proteins to show up in citrus fruit, trees, and cell cultures," McDonald says. "We plan to use these elicitors in citrus, other fruits, and vegetables."

Any proteins elicited by these compounds will need to be characterized to determine which are plant defensive. Plant breeders will need to know which proteins to select to produce new, improved citrus varieties that can defend themselves.

Genetically engineered plants that do not require a foreign gene are generally regarded as safe by the U.S. Food and Drug Administration. Therefore, Mayer expects that FDA review would not be necessary, since these defensive proteins are already present in plants and nothing foreign is being introduced.—By **Doris Stanley**, ARS.

*Scientists mentioned in this article can be reached at the USDA-ARS U.S. Horticultural Research Laboratory, 2120 Camden Road, Orlando, FL 32803; phone (407) 897-7300, fax (407) 897-7309.* ◆

KEITH WELLER



**Chemist Merle Carr installs a transducer to disclose internal pressure as ingredients surge through. (K5500-1)**

# Twin-Screw Extruder Transforms Starch

*More versatile and energy efficient than batch processing, the reactive extrusion process allows for a quick change of product with no shutdown time.*

Today's powdery mountains of dry cornstarch could be tomorrow's high-tech, economical, and environmentally friendly resins, adhesives, packing materials, and other goods—with some help from a machine called a twin-screw extruder.

Starch-based plastic products such as biodegradable cutlery and garbage bags have already made headlines. Now chemist Merle E. Carr at ARS' National Center for Agricultural Utilization Research (NCAUR) in Peoria, Illinois, is using a pilot-scale twin-screw extruder to explore further the potential of cornstarch for industrial uses.

Carr is studying how starch changes physically and chemically as it undergoes continuous processing in an extruder. This processing, known as "reactive extrusion," could lead to new multi-million-pound markets for starch-derived chemicals and polymers, much as oil refining led to a myriad of petrochemical products.

Extruders are not new on the American industrial scene. They've been used for decades to cook, melt, blend, and shape breakfast cereals and other foods and for processing plastics into industrial and consumer products. But not until the 1980's did technology begin to accelerate for reactive extrusion processes.

Extruder-processed starch might be used to encapsulate pesticides for slower, more effective release, while at the same time lessening the pesticide's impact on the environment.

Other potential uses for extruded starch include cosmetics, coatings,

and urethane foams for packing material, building insulation, or even a "first home" for seedling plants. Several companies have signed agreements to collaborate in research and product development at the center.

Carr says some of the appeal of reactive extrusion lies in its versatility and other advantages over industry's typical batch processing.

With the twin-screw extruder, continuous processing can be switched from making one type of product to another, depending on changing needs, with little or no shutdown time. Extrusion processing can also be considerably faster than batch processing, completing the reaction in minutes rather than hours.

Reactive extrusion may be particularly well suited for quick starch graft copolymerization—the coupling of synthetic chemicals made from petroleum with biopolymers from starch.

A case in point is a 1970's invention called Super Slurper. Developed from cornstarch by a team of ARS scientists led by chemist William M. Doane, highly absorptive Super Slurper has found a place in body powders, diapers, absorbent soft goods, batteries, fuel filters, soil additives, and other materials.

Carr and his colleagues made a starch-polyacrylonitrile graft copolymer, a precursor of Super Slurper, in about 6 minutes. In contrast, a batch process took 2 hours.

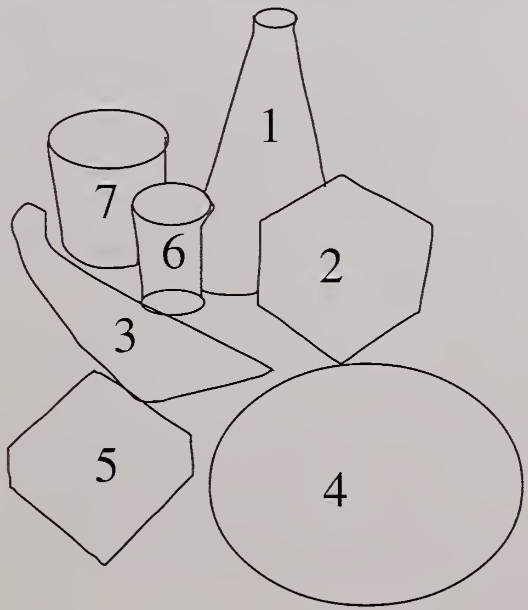
## The Reactive Extrusion Process

Making graft copolymers by reactive extrusion could give starch a welcome boost in markets where starch products have lost competitiveness, Carr says. For example, the researchers have found that a combination of starch and acrylamide had similar adhesive strength in pigmented paper coatings as nonstarch materials such as polyvinylalcohol and styrene-butadiene.

At NCAUR, reactive extrusion of cornstarch begins with the flow of dry starch granules from a hopper into the extruder. There, intermeshing side-by-side augers mix the starch with chemicals added to react under rapidly changing pressures and temperatures inside the extruder. Pushed to the machine's end, the resulting starch derivatives squeeze through a die—shaped by slits, round holes, or other openings. They may be later cut to length.

KEITH WELLER


**Products of twin-screw processing include fluid glycosides (1) for making rigid polyurethane foam blocks (2), starch-encapsulated herbicide strands (3) that can be made into granules (4), semi-flexible polyurethane foam with starch filler (5), cationic starch (6), and the famous superabsorbent starch, Super Slurper (7). (K5501-1)**



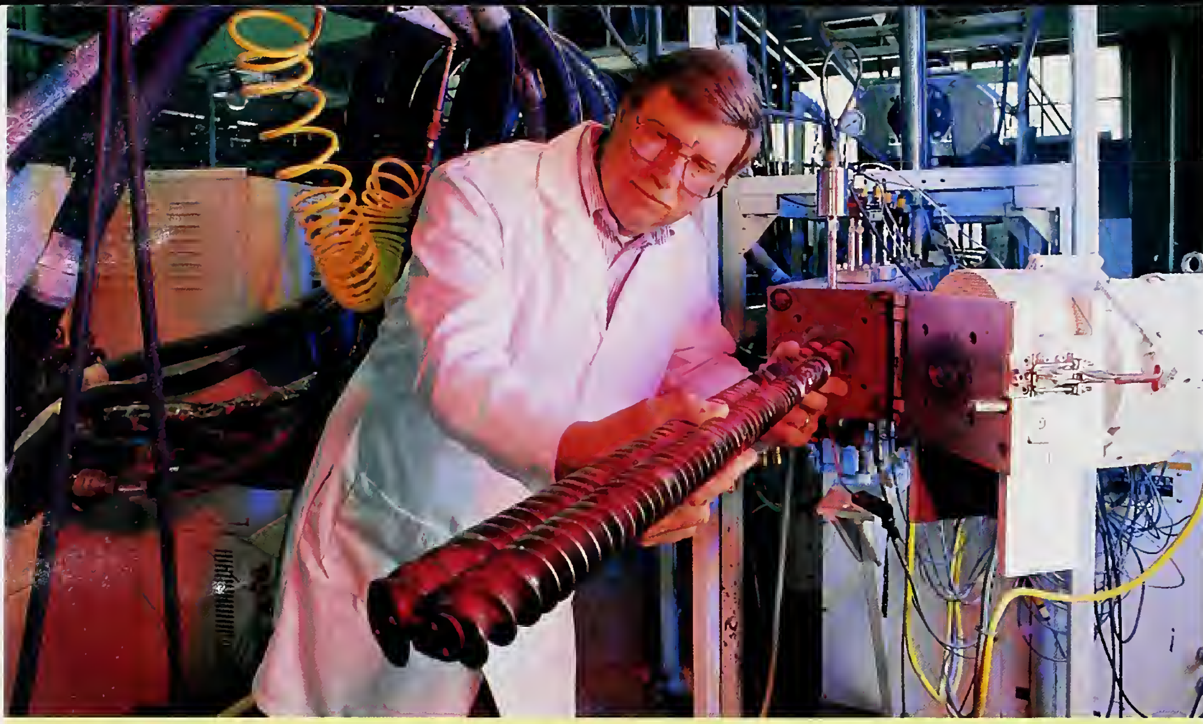

Besides being versatile, reactive extrusion is generally more energy-efficient and effective than batch processing, says Carr.

Without the twin-screw extruder's thorough mixing capability, some chemical reactions could not be done practically. Extrusion technology allows starch with little or no water to be melted and broken into molecules or mixed and reacted with other materials.

Carr illustrates the versatility of the twin-screw extruder with a foot-long model made partly of transparent plastic. This model shows that individual slip-on screw elements can be configured to control mixing and flowing actions. Screws shaped for kneading, for example, can uniformly distribute friction-generated heat for chemical reactions that depend on precise temperatures. Reverse pitch screws at certain points can slow down materials to enhance mixing or feeding of new materials.

Also, twin-screw extrusion could be used to produce chemical intermediates such as glycosides for the manufacture of both new and existing products. Glycosides—formed from starch and ethylene glycol, for example—are now used to make products such as coating resins, detergents, and cosmetic moisturizers.

Carr processed glycol glycosides with propylene oxide to form polyether polyols. He and chemist R. Leo Cunningham demonstrated that these polyols could serve as alternative chemicals in the manufacturing of rigid polyurethane foams. Such



JACK DYKINGA

Before processing cooked bean flour, engineer Richard Edwards inspects the 7-foot augers of a twin-screw extruder. (K5144-6)

foams, used for packaging and insulation, now make up a multi-billion-dollar industry.

Starch-encapsulated pesticides are another potentially large market. Carr has patented this use of the twin-screw extruder with coinventors Doane, Robert E. Wing, and Edward B. Bagley, also at NCAUR.

Carr says the encapsulation of pesticides for slow release lessens problems associated with their use such as pesticide decomposition, leaching, groundwater contamination, and the hazard of handling toxic materials.

With a twin-screw extruder, herbicide encapsulation is readily adaptable to conventional industrial production, Carr says, and requires less energy than batch processing. Also, more herbicide can be concentrated into the starch and formulated for more precisely timed release.

To encapsulate pesticides, unmodified cornstarch is gelatinized in the extruder. Further along in the processing, biologically active materials are incorporated into the mixture.

Additional processing by pelletizing, conveying, and drying equipment results in uniformly sized granules of the encapsulated material for ease of application.

ARS scientists at other locations are conducting field studies on the impact of starch-encapsulated herbicides on potential groundwater pollution. Also under study are encapsulated alachlor, metolachlor, atrazine, and other herbicides—alone and in combinations—for controlling various weed species on different soil types.—By **Ben Hardin,** ARS.

*Merle E. Carr and other scientists mentioned by name in this article are at the USDA-ARS National Center for Agricultural Utilization Research, 1815 N. University Street, Peoria, IL 61604; phone (309) 685-4011, fax (309) 681-6686.* ◆

## Extruder Speeds Bean Flourmaking

A nutritious, inexpensive white flour from small white beans could be ready in about 10 minutes, using a grinder, miller, and twin-screw extruder.

"That's faster than the traditional approach, which requires soaking the beans in water, cooking them in mammoth kettles, mashing them into a paste, drying the paste, and then grinding the paste into powder," says Richard H. Edwards at the ARS Western Regional Research Center in Albany, California. "Extrusion uses less energy, and it doesn't leave cooking water that's a hassle to dispose of.

"We hope the advantages of extrusion processing," he says, "will encourage food manufacturers to take a new look at bean flour as a convenient, healthful ingredient.

"White bean flour has a mild flavor and attractive color," adds Edwards. "Used in moderate amounts, it won't interfere with the taste of foods."

Small whites and other dry beans—like navy or pinto—are a good source of protein, fiber, and folate (a B vitamin), as well as iron, phosphorus, potassium, and magnesium.

Edwards expects extruded bean flour to have the same cooking and baking qualities as conventionally prepared bean flour. That could make extruded flour an ideal ingredient for creamy soups and gravies, and for breads, muffins, breakfast cereals, pancakes, cookies, and other foods.

The extruder converts freshly ground, uncooked beans into a crisp, edible, ropelike strand that, after cooling, is easily milled to yield a light, fine-textured flour.

In tests, Edwards and colleagues used different die configurations, amounts of water, and temperatures. An engineer, Edwards worked with chemists Robert Becker, Albert P. Mossman, and Gregory M. Gray and statistician Linda C. Whitehand, also of ARS at Albany.

"We think we're the first to test whole, uncooked beans—with the exception of soybeans—in a twin-screw extruder," notes Edwards. "And though we used only small white beans, we expect the extruder to work just as well with other kinds."—By **Marcia Wood,** ARS.

*Richard H. Edwards is in the USDA-ARS Cereal Product Utilization Research Unit, Western Regional Research Center, 800 Buchanan St., Albany, CA 94710; phone (510) 559-5852, fax (510) 559-5777.*

## Improved Vaccine for Cattle Shipping Fever

Shipping fever, or pneumonic pasteurellosis, can infect all U.S. cattle, sheep, and goats. U.S. cattle producers lose about $1 billion annually to this disease.

ARS microbiologist Kim A. Brogden at the National Animal Disease Center (NADC) in Ames, Iowa, says that the disease is caused by the bacterium *Pasteurella haemolytica.*

"Many veterinary products that contain *P. haemolytica* to enhance immunity are available, but their effectiveness is questionable. In fact, the disease is as prevalent as ever," says Brogden.

There are 16 different types of the bacterium, but type A1 is the most common cause of contagious respiratory infections in calves and adult cows. The bacterium is spread from animal to animal after contact with mucous nasal secretions containing high numbers of A1.

*P. haemolytica* normally lives in the respiratory tract, but during periods of stress, pathogenic A1 organisms overwhelm the upper tract. Once inhaled into the lower respiratory tract, these organisms induce pneumonia.

Shipping fever is found in animals after shipping to feedlots, fairs, and shows, or while cows are crowded together in sale barns. Higher infection rates are found when large numbers of cattle are grouped in open feedlots, poorly ventilated areas, or totally enclosed structures.

Symptoms include fever, coughing, nasal discharge, increased respiratory rate, depression, and decreased appetite.

In beef cattle, animals can die—or at best grow poorly and need more time and feed to reach market weight— resulting in a higher cost of beef for the consumer.

In laboratory trials with sheep, the researchers created a more effective vaccine by combining an immune booster and a purified bacterial component of *P. haemolytica.* The resulting vaccine prevented bacterial infection in the lungs of vaccinated sheep exposed to the bacterial organism. Louis Chedid, M.D., of VACSYN, a biologics company in Paris, France, and Tampa, Florida, developed the immune booster—a synthetic enhancement called muramyl dipeptide.

Brogden and Chedid have been working together to develop the new vaccine under the terms of a research and development agreement between VACSYN and USDA.

Field trials were done at NADC to examine the effectiveness of the modified vaccine in cattle.

"The new vaccine, which was used on 30 calves," Brogden says, "was effective in preventing disease after experimental exposure to the organism. Vaccinated calves had minimal lung lesions and low numbers of *P. haemolytica* in the lungs, compared to unvaccinated calves."

ARS and VACSYN have patented the co-invention. VACSYN has been granted an exclusive license to further develop the technology into a veterinary product.—By **Linda Cooke,** ARS.

*Kim A. Brogden is at the USDA-ARS National Animal Disease Center, P.O. Box 70, Ames, IA 50010; phone (515) 239-8593, fax (515) 239-8458.* ◆

## Reduced Tillage Helps Build Soil Carbon

Conservation tillage is a good way to build up soil carbon and boost plant production on sandy soils, Agricultural Research Service scientists report.

That was the key finding in a 14-year study that was the first to measure long-term carbon levels in the sandy soils of the Southeastern Coastal Plains farmed under conservation tillage.

"The sandy soils in this region are often low in carbon, the primary element in organic matter that helps reduce erosion, holds water and nutrients, and improves overall soil quality," says Patrick G. Hunt, who is in charge of the ARS Coastal Plains Soil, Water, and Plant Conservation Research Center in Florence, South Carolina. He and ARS colleagues Terry A. Matheny at Florence and Douglas L. Karlen at the National Soil Tilth Research Laboratory in Ames, Iowa, conducted the study.

Beginning in 1979, they rotated corn, cotton, soybeans, and wheat in two different systems: conservation tillage, with a minimal disturbance of the soil surface, and traditional tillage in which soil is disked.

After 14 years, carbon in the top 6 inches of soil on conservation tillage fields nearly doubled, while carbon did not increase on the other plots. Crop yields were equal on conservation and conventionally tilled fields.

"Conservation tillage boosts carbon by keeping plant residue on the soil surface, where microorganisms break the residue down more slowly than if it is plowed into the ground," Hunt says.—By **Sean Adams,** ARS.

*Patrick G. Hunt is at the USDA-ARS Coastal Plains Soil, Water, and Plant Conservation Research Center, Box 3039, Florence, SC 29502; phone (803) 669-5203, fax (803) 669-6970.* ◆

# Forestalling Citrus Shrinkage

That shriveled-up orange that's been sitting in the fruit bowl for a couple of weeks, looking more like a golf ball each day, may be a thing of the past.

ARS chemist Robert D. Hagenmaier has found a way to keep citrus looking and tasting fresh for up to 3 weeks without refrigeration. The key, he says, is a new coating he's developed that reduces shrinkage and allows the fruit to breathe.

Oranges and grapefruit are routinely coated in citrus packinghouses to make fruit more attractive and reduce shrinkage. But that protection falls far short of what's given by this new coating.

Hagenmaier explains that conventional coatings can plug fruit pores or form an additional barrier through which gas must permeate. Even though fruit has been harvested, it must still exchange gasses through its skin. When this is restricted by blockage of the pores on the fruit's surface, deterioration begins.

"Because the fruit can breathe through the new coating, there is less chance of off-flavors developing," he says. "This is because of lower internal carbon dioxide concentrations, which means that there is better gas exchange between the air and the fruit."

Hagenmaier plans to test formulations of his coating on other kinds of fruit in his research at the ARS Citrus and Subtropical Products Laboratory in Winter Haven, Florida.

"The coating formulations we've had the best results with consist mainly of wax, which is what fruits and vegetables are naturally coated with," he says. "We also use minimum amounts of resins commonly used by the fruit packing industry." All the coating ingredients have already been approved by the U.S. Food and Drug Administration.

In laboratory tests, Hagenmaier applied the new coatings to oranges and grapefruit and compared them with fruit that had been treated with different coatings now in commercial use. The results showed that after 3 weeks at room temperature, fruit treated with the new coatings still looked good and showed no signs of deterioration, while fruit treated with commercial coatings appeared shrunken and discolored.

"When freshly applied, our coatings don't look as shiny as those used commercially," Hagenmaier says. "But, since ours retard shrinkage, they keep fruit looking shiny longer."

Shine is largely a marketing tool. There is no government standard that says fruit must shine.

"Glossy or not, a damage-free piece of fruit would grade the same," says Paul Manol, assistant head of grading for the fresh products branch of USDA's Agricultural Marketing Service.—By **Doris Stanley**, ARS.

*Robert D. Hagenmaier is at the USDA-ARS Citrus and Subtropical Products Research Laboratory, P.O. Box 1909, Winter Haven, FL 33880; phone (813) 293-4133, fax (813) 299-8678.* ◆

WALTER CALAHAN

# Science Update

## Mineral Supplements Could Strengthen Preemies' Bones

Very premature infants have a better outlook for strong bones if they temporarily get extra calcium and phosphorus in intravenous feedings, according to a new ARS study. The bones of these infants fracture easily because of low mineral content—a consequence of completing their development outside the mother's uterus. In the study, 12 infants—all weighing under 2 pounds at birth—received additional intravenous calcium and phosphorus for 2 to 4 weeks. They had a higher bone-mineral content than 12 infants not receiving the minerals. The results promise to reduce the risk of fragile bones, if preemies continue on mineral-fortified milk when they are able to suckle. *Richard J. Schanler, USDA-ARS Children's Nutrition Research Center, Houston, Texas; phone (713) 798-7176.*

## Legume Finds Fall Niche in Florida

*Stylosanthes giuanensis,* nicknamed stylo, is a forage legume that could fill the late-fall nutritional gap in Florida beef pastures. Stylo matures in October and November, at a time when other legumes such as hairy indigo and alyce clover have faded but winter pastures aren't ready. Currently, cattle graze tropical grasses such as bahiagrass in the fall, though they usually don't gain weight. Stylo offers 7 to 9 percent more crude protein and 30 to 35 percent more digestible dry matter than mature bahiagrass. And stylo's 3 tons of dry matter per acre are comparable to the other legumes. *Mimi J. Williams, USDA-ARS Subtropical Agricultural Research Station, Brooksville, Florida; phone (904) 796-3385.*

## ARS Releases Breeding Line of Pummelo, Exotic Citrus

The pummelo, an exotic citrus fruit from the Far East, looks like a giant grapefruit, has a lemon-colored rind, "eats" like an orange, and has a sweet taste. Seed planted in 1947 formed the basis for a pummelo breeding line released by ARS. Called US 145, the line is not a commercial variety but could be used to develop one suitable for subtropical areas such as southern Florida and parts of California. It has more cold hardiness than other pummelos, a trait inherited from one of its parent plants—a tree called trifoliate orange. A pummelo fruit typically weighs about 3 pounds and measures 6 to 8 inches in diameter. You eat the light-yellow, solid fruit after peeling the rind and separating the fruit sections. *Herb C. Barrett or Randall E. Driggers, USDA-ARS U.S. Horticultural Research Laboratory, Orlando, Florida; phone (904) 787-6668.*

RANDALL SMITH

**Pummelo. (94-51)**

## Grazer Ryegrass Grows Winter Forage for the South

Cattle gained weight 20 percent faster and produced 50 percent more beef. Those were benefits of their grazing two bermudagrasses overseeded with Grazer, a new annual ryegrass, compared to having only bermudagrasses on the menu. ARS and the University of Georgia released Grazer last year. Several companies are interested in producing seed. Grazer begins maturing in April, a month before most annual ryegrasses on the market. And since it can be overseeded on bermudagrass and other perennials, cattle can feed on Grazer in winter and on the perennials after they resume spring growth. Grazer was evaluated in Georgia, Florida, North Carolina, Alabama, and Texas. *Wayne W. Hanna, USDA-ARS Forage and Turf Research Unit, Tifton, Georgia; phone (912) 386-3177.*

## Bacteria Could Guard Potato Bins from Fungi

Natural bacteria attack the fungus that causes dry rot, a disease that normally ruins 5 to 20 percent of potatoes in storage. The dry-rot fungus, *Fusarium sambucinum,* enters a tuber through wounds in the skin. It often resists chemical controls, but several beneficial bacteria are known to attack the fungus. To evaluate their commercial potential, ARS has entered into a cooperative R&D agreement with United Agricultural Products, Inc., of Greeley, Colorado. Four bacteria strains will be tested in large-scale trials under commercial storage conditions. ARS researchers are seeking to patent the bacteria's use. *David A. Schisler, USDA-ARS Fermentation Biochemistry Research Unit, Peoria, Illinois; phone (309) 681-6284.*

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## Upcoming in the AUGUST Issue

- Diagnostic tools now in the works may simplify and speed up—and in some cases, make possible for the first time—quick identification of costly livestock diseases.

- What should be done with millions of acres of Conservation Reserve Program land that will be coming back into production beginning in 1995?

- A small, fuzzy, parasitic fly found in Korea and Germany could help protect America's forests from the destructive gypsy moth.